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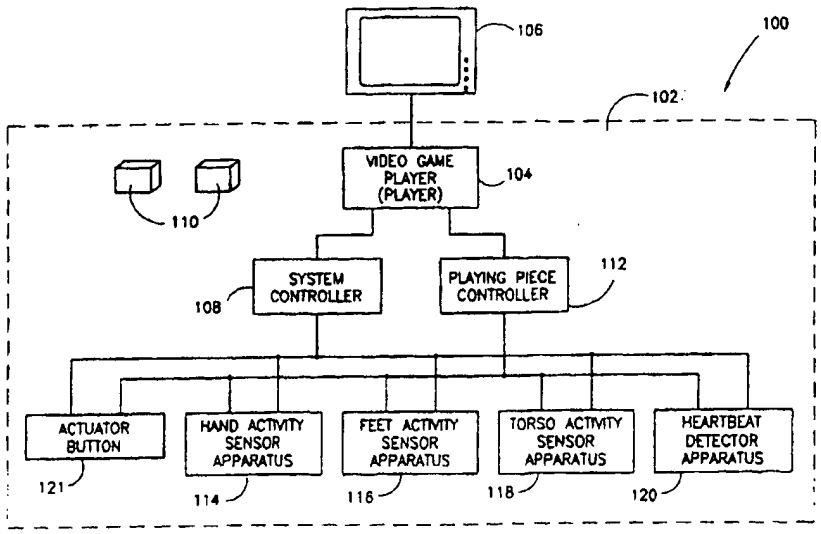

(57) Abstract

A user controlled combination video game apparatus (102) and exercise system. The system includes video game apparatus for displaying an interactive video game (110) requiring user participation. The interactive video game includes a playing piece. The system also includes hand activity sensor apparatus (114) for providing a signal associated with the independent and unconstrained movement of each of a user's hands for determining at least one aspect of the playing piece within said interactive video game and a playing piece. The system can also include feet activity sensor apparatus (116) for providing a signal associated with an activity executed by the user's feet, and torso activity sensor apparatus (118) for providing a signal associated with an activity executed by the user's torso for determining at least one aspect of the playing piece within the interactive video game.

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A USER CONTROLLED COMBINATION VIDEO GAME AND EXERCISE SYSTEM

FIELD AND BACKGROUND OF THE INVENTION

The present invention relates to user controlled combination video game and exercise systems in general and in particular to those user controlled combination video game and exercise systems which require both effort and time-space coordination on behalf of the user.

Various patents have attempted to integrate video game apparatus with exercise devices for encouraging users to maintain a regular exercise program by providing fun, challenging and self-motivating environments.

For example, U.S. Patent 4,278,095 to Lapeyre describes a treadmill and a monitor for displaying the user's speed and distance and a variable speed outdoor exercising scene controlled by the speed of the user on the treadmill. However, the exercising scene is not interactive per se in that the user does not participate in a competitive interactive video game.

While U.S. Patent 4,925,189 to Braeunig describes a body mounted video game controller which attaches to the user's upper body allowing the user to play a video game by leaning the upper body in different directions to simulate the movement of a joystick. The user may play from a standing, sitting, kneeling position and therefore this user controlled combination video game and exercise devices suffers from the disadvantage that the user is not required to engage in intense physical activity during a training session.

And while U.S. Patent 4,720,789 to Hector et al. describes a video exercise or game floor controller with location indicating foot pads which allow an operator to input information into the system by locating his feet on foot pads of the floor controller. The game floor controller can also include light segments associated with each of the foot pads to encourage rapid foot movement by the fast switching on and off of different light segments. However, the apparatus does not measure whether the user is

merely shifting his weight from one foot to the other foot in a tap dancing style or whether the user is sustaining intense physical activity, for example, by running on the spot.

Other developments include adjusting the video game difficulty level upon the effort executed by the user during exercise. Typically the difficulty level of the video game is regulated such that the heartbeat of the user remains within a pre-determined specified target zone. The exercise is executed on an exerciser such as a treadmill, standing bicycle, standing rowing machine, and the like including speed sensors for indicating the effort executed by the user. Examples of such exercisers are described in U.S. Patents 4,489,938 to Darzinskis, 4,512,567 to Phillips, 4,542,897 to Melton et al., 4,637,605 to Ritchie, 4,660,828 to Weiss, 4,709,917 to Yang, 4,711,447 to Mansfield, 4,817,950 to Goo, 5,001,632 to Hall-Tipping, 5,054,771 to Mansfield, 5,139,261 to Openiano, 5,148,152 to Stuekle et al., 5,195,746 to Boyd et al. and 5,277,678 to Friedabach and 5,308,296 to Eckstein.

The existing devices evaluate physical effort either by monitoring the device itself or by the monitoring the heartbeat of the user. The monitoring of the device itself suffers from the disadvantage that the aerobic effort expended in activities which are not performed directly on the device cannot be monitored. The disadvantage of monitoring the user's heartbeat is that the heartbeat is a subjective measurements which depends on the condition and fitness of the specific user and does not constitute an objective determination which can be used to compare a number of users as in an actual sports game.

Therefore, there is a need for a user controlled combination video game and exercise device while overcoming the deficiencies of the above-mentioned apparatus. More specifically, there is a need for a device which monitors both the activity of the user and an objective physical parameter which does not depend on the condition and fitness of the user and which,

as a result, makes it possible to evaluate activities which cannot be properly evaluated heretofore, such as, for example, running in place, jumping, knee lifts in the sitting position, and the like.

SUMMARY OF THE INVENTION

The present invention is for a user controlled combination video game and exercise system which encourages the user to engage in intense aerobic activity during a challenging and motivating training session. In addition, the system can be employed for user participation in a wide range of recreational activities, such as dancing, and the like.

Hence, there is provided according to the present invention, a user controlled combination video game apparatus and exercise system, the system comprising: (a) video game apparatus for displaying an interactive video game requiring user participation, the interactive video game including a playing piece; (b) limb activity sensor apparatus for providing a signal associated with the independent and unconstrained movement of at least two of a user's limbs for determining at least one aspect of the playing piece within the interactive video game; and (c) a playing piece controller responsive to the signal for controlling the playing piece.

According to a further feature of the present invention, the limb activity sensor apparatus includes a left hand activity sensor operable by the left hand of the user and a right hand activity sensor operable by the right hand of the user.

According to a still further feature of the present invention, the limb sensor apparatus includes a left foot activity sensor operable by the left foot of the user and a right foot activity sensor operable by the right foot of the user.

According to a yet still further feature of the present invention, at least a portion of the limb activity sensor apparatus is worn by the user.

According to a yet still further feature of the present invention, at least a portion of the limb activity sensor apparatus is held by the user.

According to a yet still further feature of the present invention, at least a portion of the limb activity sensor apparatus is remote from the user.

According to a yet still further feature of the present invention, at least a portion of the limb activity sensor apparatus is associated with an exercise apparatus on which the user exercises.

According to a yet still further feature of the present invention, the exercise apparatus provides information associated with an activity executed by the user.

According to a yet still further feature of the present invention, the limb activity sensor apparatus includes an actuator button.

According to a yet still further feature of the present invention, the playing piece controller controls one aspect of the playing piece selected from the following group: the number of pixels moved by the playing piece per screen refresh, the size of the playing piece, the shape of the playing piece, the color of the playing piece, the location of the playing piece, the direction of movement of the playing piece, the firing rate of the playing piece, and the interaction of the playing piece with other objects on the screen.

According to a yet still further feature of the present invention, the interactive video game is played between the user and another user.

According to a yet still further feature of the present invention, the system further comprising torso activity sensor apparatus for providing a signal associated with an activity executed by the user's torso for determining at least one aspect of the playing piece within the interactive video game.

According to a yet still further feature of the present invention, at least a portion of the torso activity sensor apparatus is worn by the user.

According to a yet still further feature of the present invention, at least a portion of the torso activity sensor apparatus is associated with an exercise apparatus on which the user exercises.

According to a yet still further feature of the present invention, the system further comprising a heartbeat detector apparatus for providing a signal associated with an activity executed by the user for determining at least one aspect of the playing piece within the interactive video game.

According to a yet still further feature of the present invention, the system further comprising a system controller responsive to the signal for controlling at least a portion of the system.

According to a yet still further feature of the present invention, the system controller controls at least one feature of an exercise apparatus.

According to a yet still further feature of the present invention, the system further comprising strain sensors for detecting the force applied by at least one limb of the user.

There is also provided apparatus for measuring aerobic activity executed by a user, the apparatus comprising: (a) at least one sensor for detecting the impact frequency of at least one of the user's feet on a surface; and (b) at least one sensor for detecting the percentage of time that at least one of the user's feet is on a surface.

There is still further provided a user controlled combination video game apparatus and exercise system, the system comprising: (a) video game apparatus for displaying an interactive video game requiring user participation, the interactive video game including a playing piece; (b) activity sensor apparatus for providing a signal associated with the ambulatory speed of a user for determining at least one aspect of the playing piece within the interactive video game; and (c) a playing piece controller responsive to the signal for controlling the playing piece.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is herein described, by way of example only, with reference to the accompanying drawings, wherein:

FIG. 1 shows a block diagram of the preferred embodiment of a user controlled combination video game and exercise system constructed and operative according to the teachings of the present invention;

FIGS. 2a and 2b depict a Squash video game screen and a Squash video game instruction screen, respectively, according to the teachings of the present invention;

FIGS. 2c and 2d depict a Survival Training video game screen and a Survival Training video game instruction screen, respectively, according to the teachings of the present invention;

FIG. 2e depicts a Badminton Training video game screen according to the teachings of the present invention;

FIG. 2f depicts a Dance Training video game screen according to the teachings of the present invention;

FIGS. 3a-3d depicts several representative system control screens provided by the video game apparatus of the system including a Start Training Session screen, a Select Video Game screen, a Select Difficulty Level screen and a Select Training Duration screen, respectively;

FIG. 4 shows a schematic illustration of a first embodiment of the user controlled combination video game and exercise system of Figure 1 in which the aerobic activity sensor apparatus includes transmitters worn by the user and receivers integrated with the video game apparatus of the system;

FIG. 5 shows a schematic illustration of the first embodiment of the user controlled combination video game and exercise system of Figure 1 being used by two users concurrently;

FIG. 6 shows a schematic illustration of a second embodiment of the user controlled combination video game and exercise system of Figure 1

in which the aerobic activity sensor apparatus includes transmitters worn by the user and receivers integrated with an exercise apparatus configured as an exercise mat;

FIG. 7 shows a schematic illustration of a third embodiment of the user controlled combination video game and exercise system of Figure 1 in which the aerobic activity sensor apparatus includes feet sensors and hand activity sensors integrated with an exercise apparatus configured as an exercise mat;

FIG. 8 shows a schematic illustration of a fourth embodiment of the user controlled combination video game and exercise system of Figure 7 in which the exercise mat is rotatably mounted on a base;

FIGS. 9a and 9b show a schematic illustration of a fifth embodiment of the user controlled combination video game and exercise system including a treadmill;

FIGS. 10a-10c show three operative positions of the hand activity sensors for detecting three heights of one of the user's hand;

FIGS. 11a and 11b show schematic illustrations of hand activity sensors for detecting direction of movement of a user's hands along one axis and along two axes, respectively;

FIG. 12 shows a table entitled "Speed of User's Playing Piece as a Function of the Level of Aerobic Activity of the User as measured by Foot Sensors"; and

FIG. 13 shows a table entitled "Speed of User's Playing Piece as a Function of the Hand Speed of the User as Measured by Hand Sensors".

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is of a user controlled combination video game and exercise system.

The principles and operation of the user controlled combination video game and exercise system of the present invention may be better

understood with reference to the drawings and the accompanying description.

With reference now to the drawings, Figure 1 shows a block diagram of a user controlled combination video game and exercise system, generally designated **100**, constructed and operative according to the teachings of the present invention. Generally speaking, user controlled combination video game and exercise system **100** of the present invention marries the intense concentration and total involvement required by a user in playing a challenging interactive video game with exercise. However, at the same time, system **100** can be employed for non-strenuous recreational activities, for example, for instructing dancing, and the like. In both cases, system **100** requires skilful co-ordination in the manner in which the user executes an activity in response to events taking place within the video game.

Hence, system **100** includes video game apparatus **102** including a video game controller **104** for displaying an interactive video game on a display **106** observable by a user. Display **106** is preferably a conventional TV monitor and therefore the connection between video game apparatus **102** and display **106** is achieved in a similar fashion as between a video player and a TV monitor. Alternatively, display **106** can be a dedicated monitor, a projected screen, a hologram and similar display system. Video game apparatus **102** also includes a system controller **108** for controlling the operation of user controlled combination video game and exercise system **100**. System controller **108** controls such operations as initiating a training session, selecting a video game, selecting a game difficulty, selecting the duration of a training session, providing a summary of pertinent information regarding the performance of the user, and the like. In addition, system controller **108** can be used for regulating a feature of an exercise apparatus, for example, the resistance of a treadmill.

Video game apparatus **102** is preferably designed to accept cartridges **110** wherein each cartridge **110** provides interactive video games of a particular type. The video games can also be classified according to other criteria, for example, number of users. The number of users can be one, two or more. In the case of a single user, the user plays against video game apparatus **102** while in the case of two or more users, the users can play either against each other or against video game apparatus **102**.

The interactive video games are typically competitive sport-type games, arcade-type games, Gameboy-type games, and the like for encouraging the user to engage in intense aerobic activity and to maintain an intensive training schedule. Sport-type games can include racket games, for example, squash, tennis, ball games, for example, football, basketball, and other games such as boxing, adventures, indoor activities, outdoor activities. Arcade-type games can include, for example, Tetrus™, Pacman™, etc. Furthermore, the competitive interactive video games can include queries, for example, mathematical problems, logic problems, and the like which the user is required to answer during a session on system **100** such that the user is challenged both on the physical level and on the cognitive level.

The competitive interactive video games of video game controller **104** include one or more playing pieces under the control of a playing piece controller **112**. The playing pieces depend on the nature of the video game in question. Typical playing pieces include, but are not limited to, a racket in a racket game, a player in a ball game, a "monster" in a Pacman™ game, and the like. Also, the playing piece can be hidden within in the video game, the whole screen, and the whole scenario. In principle, playing piece controller **112** controls the playing piece in such a fashion that the user is more likely to achieve a higher score, a victory or similar desirable game outcome through increasing his level of effort. However, as will become apparent below, it is not the mere level of effort which

secures a desirable game outcome but also the skilful time and space co-ordination, and response to queries, if any, as practiced by the user while participating during the ongoing video game as displayed on display **106**.

However, it should be noted that the term "interactive video game" also refers to a wide range of low aerobic intensity simulation scenarios, animation scenarios, virtual reality scenarios, and the like as known in the art. For example, a simulation scenario can include a training session for teaching how to dance a dance, how to perform judo exercises, gymnastic activities, and the like. In the case of teaching dancing, the user can be represented as one member of a dancing couple while video game apparatus **102** provides the second member of the dancing couple. Hence, the member of the dancing couple representing the user is the playing piece under the control of playing piece controller **110**. Alternatively, two users can dance together. In both cases, the desirable game outcome can be a score similar to that given in conventional dancing competitions. As before, it can be readily appreciated that the interactive video game outcome requires skilful time and space co-ordination on behalf of the user.

System controller **108** and playing piece controller **112** receive input from one or more sources including hand activity sensor apparatus **114**, feet activity sensor apparatus **116**, and torso activity sensor apparatus **118**. Generally speaking, hand activity sensor apparatus **114** detects independent and unconstrained movement of each of the user's arms. While feet activity sensor apparatus **116** detects independent and unconstrained movement of each of the user's legs. And torso activity sensor apparatus **118** detects any independent and unconstrained movement of the user's torso. It can be readily appreciated that system **100** can include other activity sensors for detecting activity of other parts of the body, for example, the head, knees, elbows, etc.

It is a particular feature of the present invention that within the context of the present invention, independent movement implies that the

limbs of the user can move independently of each other, i.e. the left arm can be moved upwards while the right arm remains stationary, rather then being constrained to execute a common motion or an opposing motion, for example, when gripping handlebars of a bicycle, manipulating oars of a rowing boat, and the like. It is a further feature of the present invention that within the context of the present invention unconstrained movement implies that the limbs of the user can be moved in any natural movement rather then being constrained to execute a specific movement, for example, turning the handlebars of a bicycle, running along a treadmill, riding a bicycle, and the like.

Hand activity sensor apparatus **114**, feet activity sensor apparatus **116**, and torso activity sensor apparatus **118** typically each include a Look-Up-Table having a "game value" for the manner in which a particular activity is executed. The manner in which "game values" are awarded for movements demanding a greater expenditure of aerobic energy or greater space-time co-ordination depend on the type of video game. For example, in a tennis video game, a greater expenditure of aerobic energy can be used for increasing the speed of the racket of the user. While, in a Pacman video game, a greater expenditure of energy can be used for slowing down a "monster" trying to catch the user. And while in a dance teaching video game, a more difficult step can be give a greater "game value".

The likelihood of achieving a higher score, a victory or other desirable game outcome is correlated to the activity executed by the user through adapting one or more features of the playing piece. First, playing piece controller **112** can control the maneuverability of a playing piece such that its maneuverability is a function of the level of aerobic activity of the user or the level of time-space coordination displayed by the user. Maneuverability typically refers to the "speed" and "location" of the playing piece given in terms of the number of pixels moved within each screen refresh of display **106**. Second, playing piece controller **112** can

control the size of a playing piece such that its size is a function of the level of aerobic activity of the user or the level of time-space coordination displayed by the user. Third, playing piece controller **112** can control the "firing rate" of a playing piece such that the firing rate is a function of the level of aerobic activity of the user or the level of time-space coordination displayed by the user. Fourth, playing piece controller **112** can control the shape of the playing piece such that its shape is a function of the level of aerobic activity of the user or the level of time-space coordination displayed by the user. Fifth, playing piece controller **112** can control the color of the playing piece such that its color is a function of the level of aerobic activity of the user or the level of time-space coordination displayed by the user. And sixth, playing piece controller **112** can control the interaction of the playing piece with other objects in a video game such that its interaction is a function of the level of aerobic activity of the user or the level of time-space coordination displayed by the user.

Furthermore, system controller **108** and playing piece controller **112** can also receive input from a heartbeat detector apparatus **120**. Heartbeat detector apparatus **120** can be employed, for example, for terminating a training session when the heartbeat of a user exceeds a pre-determined value according to his age, general state of fitness, etc. Alternatively, heartbeat detector apparatus **120** can be employed instead of hand activity sensor apparatus **114**, feet activity sensor apparatus **116**, or torso activity sensor apparatus **118** for providing input regarding the level of aerobic activity executed by a user. Still further, system controller **108** and playing piece controller **112** can also receive input from actuator buttons **121** employed on hand activity sensor apparatus **114**, feet activity sensor apparatus **116**, or torso activity sensor apparatus **118** as known in the art of joystick controllers and the like.

With reference now to Figures 2a-2f, the screens depict representative interactive video games playable by one or more users on user controlled video game and exercise system **100**.

Turning now to Figures 2a and 2b, Figure 2a depicts a Squash video game screen **122** while Figure 2b shows depicts a Squash video game instruction screen **124**. The purpose of the Squash video game is to keep a ball **126** within a court **128** as long as possible. This is achieved by the user moving a racket **130** located at the bottom of the screen to the left and to the right such that ball **126** rebounds off racket **130**, thereby remaining in court **128**. The number of times that the user successfully intercepts ball **126** is shown on a scoreboard **132**. In this case, the user is required to run faster to move racket **130** faster and to raise either his left or right hand to move racket **130** to the left or the right, respectively. Hence, it can be readily appreciated that the user has to display considerable bodily coordination and exert considerable aerobic activity in order to achieve a high score.

Turning now to Figures 2c and 2d, Figure 2c depicts a Survival Training video game screen **134** while Figure 2d shows depicts a Survival Training video game instruction screen **136**. The purpose of the Survival Training video game is to clear a way in a jungle **138** to reach food shown as apples **140**, to avoid being eaten by monsters **142** shown as squares and to kill one or more monsters **142** within a 3 second period after having eaten an apple **140**. This is achieved by the user moving an "action man" playing piece 144 along the pathways through jungle **138**. The number of apples **140** that the user eats and the number of monsters **142** that he kills is shown on a scoreboard **146**. In this case, the user is required to run faster to move playing piece **144** faster, to raise his left or right hand to move playing piece **144** to the left or the right, respectively, raise both arms to move playing piece **144** up and to lower both arms to move playing piece **144** down. Again, it can be readily appreciated that the user

has to display considerable bodily coordination and exert considerable aerobic activity in order to achieve a high score.

Turning now to Figure 2e, Figure 2e depicts a Badminton Training video game screen **148**. The purpose of the Badminton Training video game is to keep a ball **150** within a court **152** as long as possible. This is achieved by the user moving a racket **154** located at the bottom of the screen to the left and to the right such that ball **150** rebounds off racket **154**, thereby remaining in court **152**. The number of times that the user successfully intercepts ball **150** is shown on a scoreboard **156**. In this case, the user is required to raise either his left or right hand to move racket **154** to the left or the right, respectively. By running faster, the user can increase the size of racket **154**. In another version, the speed that the user runs determines the height of rebound of ball **150** from racket **154** such that the height of rebound increases with a faster running speed. Hence, it can be readily appreciated that the user has to display considerable bodily coordination and exert considerable aerobic activity in order to achieve a high score.

Turning now to Figure 2f, Figure 2f depicts a Dance Training video game screen **158**. The purpose of the Dance Training video game is to teach a user a dance. This is achieved by the user being represented a first member **160** of a dancing couple under the control of playing piece controller **110** while video game apparatus **102** provides a second member **162** of the dancing couple. A score is provided according to the manner in which the user performs the dance routine correctly. As before, it can be readily appreciated that the interactive video game outcome requires skilful time and space co-ordination on behalf of the user to achieve a high score.

With reference now to Figures 3a-3d, and as described with reference to several representative system control screens, hand activity sensor apparatus **114**, feet activity sensor apparatus **116**, torso activity

sensor apparatus **118** and heartbeat detector apparatus **120** can provide input to system controller **108** for controlling the operation of user controlled combination video game and exercise system **100**. In particular Figure 3a depicts a Start Training Session screen **164** in which the user is required to stand on an exercise apparatus and raise his hands to initiate a training session. While Figure 3b depicts a Select Video Game screen **166** in which the user is required to raise one hand to scroll through video games options and to raise both hands to select a particular video game that he wants to play. Figure 3c depicts a Select Difficulty Level screen **168** operative in a similar manner to the Select Video Game screen **166** except that the user is selecting a game difficulty, for example, Novice, Beginner, Intermediate and Advanced. And finally, Figure 3d depicts a Select Training Duration screen **170** operative in a similar manner to the Select Video Game screen **166** except that the user is selecting the duration of a training session.

With reference now to Figures 4-9, the schematic illustrations depict several implementations of user controlled combination video game and exercise system **100** constructed and operative according to the teachings of the present invention.

Turning now to Figure 4, hand activity sensor apparatus **114**, feet activity sensor apparatus **116** and torso activity sensor apparatus **118** are realized as transmitters and receivers couplings communicating through an IR interface, an RF interface and the like. The transmitters are typically worn by the user and the receivers are typically integrated with video game apparatus **102**. Hence, the user can execute independent and unconstrained movements of his arms and legs as long as communication between the transmitters and the receivers is maintained. In the case of an IR interface, communication is maintained along the line of sight while in the case of an RF interface communication is maintained within the range of the transmitter-receiver coupling. Typically, each transmitter emits signals

having a particular characteristic such that the signals of each transmitter can be distinguished from the signals of the other transmitters. The receivers are deployed in such a manner that they can determine the location of each of transmitters and typically sample each transmitter in sequence.

Hence, hand activity sensor apparatus **114** includes two hand sensors **172** and **174** for attaching to the user's wrists for detecting movement of the user's hands, feet activity sensor apparatus **116** includes two feet sensors **176** and **178** for attaching to the user's ankles for detecting movement of the user's feet, torso activity sensor apparatus **118** includes a waist sensor **180** for attaching to the user's waist for detecting movement of the user's torso and video game apparatus **102** includes three receivers **182-186**. Obviously, depending on the movement in question, some movements are registered by only one sensor, for example, raising the right arm is only detected by sensor **172** while other movements, for example, jumping in the air, is registered by all of sensors **172-180**. In addition, heart beat counter **120** provides the heart beat of the user during an exercise session on system **100**.

It can be readily appreciated that playing piece controller **112** is required to compute relative movements of one sensor compared to another sensor to determine the "game value" of some movements. For example, playing piece controller **112** only requires information from sensor **172** for determining the game value of an activity such as the user raising his hand from waist height to a raised height above his head while he is standing stationary. While, in the case, that playing piece controller **112** is required to determine the game value of an activity such as the user raising and lowering his hands from waist height to the same raised height while jumping up in the air, playing piece controller **112** requires information from sensors **172**, **174** and **180**. This is because the absolute movements of sensors **172** and **174** are relative to the movement of sensor **180**.

Turning briefly to Figure 5, system **100** is depicted for the concurrent exercising of two users acting as adversaries in a common interactive game. In this case, the transmitters denoted **a** transmit signals at different frequencies from those transmitters denoted **b** such that system **100** can distinguish between the movements of the two users.

In the implementation of system **100** depicted in Figure 6, the signals of sensors **172-180** are picked up by receivers **182-186** embedded in an exercise mat **188**. Again, receivers **182-186** are deployed such that playing piece controller **112** can determine the displacement of each sensor **172-180**. In this case, system **100** includes a communication link **190** between receivers **182-186** and video game apparatus **102** realized as a flexible, electric cable, an IR interface, an RF interface, and the like. Alternatively, exercise mat **188** can be provided as a stepper or as a stair-type configuration.

Exercise mat **188** is similar in many respects to conventional exercise mats in that it is fabricated from a plastic covered, heavy duty sponge substrate designed for cushioning shocks derived from executing intense aerobic activity, for example, running on the spot. Also, exercise mat **188** preferably of sufficient size such that the user can perform intensive aerobic exercise without having to pay undue attention to his position thereon so as not to constrain the independent and unconstrained movement of the user's legs.

In the implementation of system **100** depicted in Figure 7, hand activity sensor apparatus **114** includes hand sensors **192** and **194** and feet activity sensor apparatus **116** includes feet sensors **196** and **198**, both realized as pressure sensitive devices, load cells, switches, and the like integrated in an exercise mat **200**. As shown, hand sensor **192** is deployed to the right of exercise mat **200** for detecting the movement of the user's right hand and hand sensor **194** is deployed to the left of exercise mat **200** for detecting the movement of the user's left hand. Hand activity sensor

192 is actuated by an elastic cord 202 provided with a handle 204 for gripping by the user's right hand while hand sensor 194 is actuated by an elastic cord 206 provided with a handle 208 for gripping by the user's left hand so as not to constrain the independent and unconstrained movement of the user's arms. In a similar manner, foot sensor 196 is located substantially at the center of the right half of exercise mat 200 for detecting the impact of the user's right foot on exercise mat 200 while foot sensor 198 is located substantially at the center of the left half of exercise mat 200 for detecting the impact of the user's left foot on exercise mat 200. As before, communication link 190 between hand sensors 192 and 194 and feet sensors 196 and 198 and video control apparatus 102 is through a flexible, electric cable, an IR interface, an RF interface, and the like. To extend the range of activities which can be executed on exercise mat 200 and the muscles which can be exercised, modifications to exercise mat 200 can include rotatably mounting it on a base 210 as shown in Figure 8. In this case, system 100 preferably includes a hand support 211 including actuator buttons 121.

With reference now to Figure 9a and 9b, system 100 is shown including a treadmill 212 which includes a speed sensor 213 for measuring the ambulatory speed of the user on treadmill 212. It should be noted that ambulatory speed within the context of the present invention refers to any speed from a gentle walking speed to a fast running speed. In this case, speed sensor 213 replaces hand activity sensor apparatus 114, foot activity sensor apparatus 116 and torso activity sensor apparatus 118 as input to system controller 108 and playing piece controller 112. As mentioned hereinabove, system controller 108 can regulate one or more features of an exercise apparatus, for example, the resistance of treadmill 212. Again, system 100 preferably includes a hand support 211 including actuator buttons 121. As before, the user participates in an interactive active video

game which requires both physical exertion and time and space coordination to achieve a desirable game output.

With reference now to Figures 10a-10c, the principle by which hand sensors **192** and **194** measures three heights, the speed and the acceleration of the user's hands is now described. In this case, hand sensor **192** includes two normally open (NO) switches **214** and **216** and a connector **218** extending therebetween. It should be noted that cord **202** is not attached to the center of connector **218** but rather towards one of switches **214** and **216** such that switches **214** and **216** do not close concurrently. Hence, the movement of the user's right hand is determined by whether none, one or both of switches **214** and **216** are closed from their normally open states. In this case, cord **202** is connected closer to switch **214** such that switch **214** closes before switch **216** regardless of the direction of movement of the user's right hand. Turning now to Figure 10a, it can be seen that when the user holds handle **204** at waist height, then both switches **214** and **216** are open. While as shown in Figure 10b, when the user holds handle **204** at shoulder height, then switch **214** is closed and switch **216** is open. And finally, as shown in Figure 10c, it can be seen that when the user holds handle **204** at a raised height above his head, then both switches **214** and **216** are closed. The speed and acceleration of the user's hands can be derived from the time taken to move through the three different states.

With reference now to Figures 11a and 11b, it can be readily appreciated that hand sensors **192** and **194** can also be designed to detect the direction of movement along one axis or both axes in Cartesian coordinates. For detecting direction of movement along one axis, hand sensors **192** and **194** require two sensor units **220** and **222**. While, for detecting direction of movement along two axes, hand sensors **192** and **194** require three sensor units **224**, **226** and **228**.

With reference now to Figures 12 and 13, the tables depict typical examples of the manner in which playing piece controller **112** correlates one or more features of a playing piece with the user's level of aerobic activity such that the likelihood of achieving a higher score, a victory or other desirable game outcome increases with an increased level of aerobic activity. For the sake of exposition, the tables are used by playing piece controller **112** when the user is playing the Squash video game on the implementation of system **100** shown in Figure 7. Hence in this case the playing piece is the racket.

It is a particular feature of the present invention that feet activity sensor apparatus **116** determines the level of aerobic activity by taking into account two factors: the impact frequency f of the user's feet on a surface and the airborne percentage of time p of the user's feet defined as the percentage of time that both feet are airborne. It can be readily appreciated that it is not sufficient to take into account just the impact frequency by considering the amount of aerobic activity required when gently hopping from one foot to the other foot at a certain impact frequency as compared to when jogging on the spot at the same frequency as compared to running on the spot at the same frequency.

However, because of the cyclic nature of walking or running, it is typically sufficient to take into consideration the impact frequency and the airborne percentage of only one foot. Furthermore, the impact frequency can be taken of one foot while the airborne percentage can be taken of the other foot. Still further, the percentage of time that one or both of the user's feet on a surface can be measured rather than measuring the airborne percentage as described above as they are complements of one another. The surface can be a floor or alternatively an exercise apparatus, for example, exercise mat **200**.

Turning now to Figure 12, the table depicts a 5 x 6 matrix of 30 game scores for different levels of aerobic activity wherein the impact

frequency f is divided into five frequency levels: f < 1, f=1 or 2, f = 3, 4 or 5, f = 6 or 7 and f > 8 and the airborne percentage p is divided into six levels: "Heavy Walking" for when p < - 40%, "Walking" for when p is between -40% to 0%, "Jogging" for when p is between 0% to 24%, "Running" for when p is between 24% to 50%, "Fast Running" for when p is between 50% to 70% and lastly "Sprinting" for when p is > 70%. It should be noted that when p takes on a negative value, this implies that both of the user's feet are on the ground. As shown, at the lower levels of aerobic activity, for example, f = 1 or 2 and Heavy Walking, the speed of the racket is 0 pixels per screen refresh i.e. the racket does not move. In a similar fashion, at the higher levels of aerobic activity, for example, f = 6 or 7 and Fast Running, the speed of the racket is seven pixels per screen refresh.

As described above with reference to Figure 2b, the user raises his hands for moving the racket in the left and right directions. Hand activity sensor apparatus **114** can also provide a game value as to the hand speed sensed by hand sensors **192** and **194** such that the raising of the hands provides an additional input to the Squash video game. In this case, hand activity sensor apparatus **114** is responsive to the rate by which handles **204** and **208** are raised by the user for awarding him "bonus pixels" in terms of the movement of the racket.

The speed by which say handle **204** is raised can be determined by the delay time d between actuations of switches **214** and **216** (see Figures 10a-10c). With reference now to Figure 13, the delay time d is preferably divided into five levels: d > 200 msecs, d is between 160 to 200 msecs, d is between 120 to 160 msecs, d is between 90 to 120 msecs and lastly **d** is less than 90 msecs. The bonus pixels are provided as a function of the number of screen refreshes, in the example, five screen refreshes such that a total of twenty-five conditions are represented. As shown, for example, when d is greater than 200 msecs, the user receives no bonus pixels over

the next five screen refreshes while when, for example, d is less than 90 msecs, the user receives 4 bonus pixels in the first screen refresh, 3 bonus pixels in the second screen refresh, and so on.

While the invention has been described with respect to a limited number of embodiments, it will be appreciated that many variations, modifications and other applications of the invention may be made.

WHAT IS CLAIMED IS:

1. A user controlled combination video game and exercise system comprising:

(a) video game apparatus for displaying an interactive video game requiring user participation, said interactive video game including a playing piece;

(b) feet activity sensor apparatus providing a signal determining frequency of a cyclical aerobic activity and level of difficulty of said aerobic activity; and

(c) a playing piece controller responsive to said signal for controlling said playing piece within said interactive video game.

2. The system of claim 1, wherein said frequency of a cyclical aerobic activity is determined by the impact frequency of at least one of the user's feet on a floor.

3. The system of claim 1, wherein said level of difficulty of said aerobic activity is determined by the percentage of time of least one of the user's feet on a floor.

4. The system as in claim 1, wherein said feet activity sensor apparatus provides a signal determining the impact frequency of each of the user's feet on said exercise surface and the percentage of time of each of the user's feet on a floor.

5. The system as in claim 1, wherein said feet activity sensor apparatus includes an exercise surface for providing said signal.

6. The system as in claim 1, further comprising hand activity sensor apparatus for monitoring a three dimensional working space, said apparatus providing a signal determining the location of at least one of the user's hands at any location within said working place, said playing piece controller responsive to said signal for controlling said playing piece within said interactive video game.

7. The system as in claim 5, further comprising hand activity sensor apparatus for monitoring a three dimensional working space, said apparatus providing a signal determining the location of at least one of the user's hands at any location within said working place, said playing piece controller responsive to said signal for controlling said playing piece within said interactive video game.

8. The system as in claim 6, wherein at least one portion of said hand activity sensor apparatus is worn by the user, said at least a portion of limb activity sensor communicating with said playing piece controller by wireless means.

9. The system as in claim 6, wherein at least a portion of said hand activity sensor apparatus is held by the user, said at least portion of limb activity sensor communicating with said playing piece controller by wireless means.

10. The system as in claim 6, wherein at least a portion of said hand activity sensor apparatus is remote from the user, said at least a portion of hand activity sensor communicating with said playing piece controller by wireless means.

11. The system as in claim 1, further comprising a second feet activity sensor apparatus for providing a signal associated with the impact frequency of each of a second user's feet on a second exercise surface and the percentage of time that each of the second user's feet is on said second exercise surface such that said interactive video game is playable between a first user and the second user.

12. A user controlled combination video game and exercise system comprising:

(a) video game apparatus for displaying an interactive video game requiring user participation, said interactive video game including a playing piece;

(b) hand activity sensor apparatus providing at least one signal determining the distance of at least one of the user's hands from a pre-determined reference point within a three-dimensional training space; and

(c) a playing piece controller responsive to said at least one signal for controlling said playing piece within said interactive video game.

13. The system as in claim 12, wherein at least a portion of said hand activity sensor apparatus is worn by the user, said at least portion of hand activity sensor communicating with said playing piece controller by wireless means.

14. The system as in claim 12, wherein at least a portion of said hand activity sensor apparatus is held by the user, said at least a portion of hand activity sensor communicating with said playing piece controller by wireless means.

15. The system as in claim 12, wherein at least a portion of said hand activity sensor apparatus is remote from the user, said at least a portion of limb activity sensor communicating with said playing piece controller by wireless means.

16. The system as in claim 12, further comprising an exercise surface providing a signal associated with the impact frequency of each of the user's feet on said exercise surface and the percentage of time that the user's feet is on said exercise surface.

17. The system as in claim 16, wherein at least a portion of said hand activity sensor apparatus is held by the user.

18. The system as in claim 12, further comprising a second hand activity sensor apparatus providing at least one signal determining the distance of at least one of a second user's hand from a pre-determined reference point within a three-dimensional training space such that said interactive video game is playable between a first user and the second user.

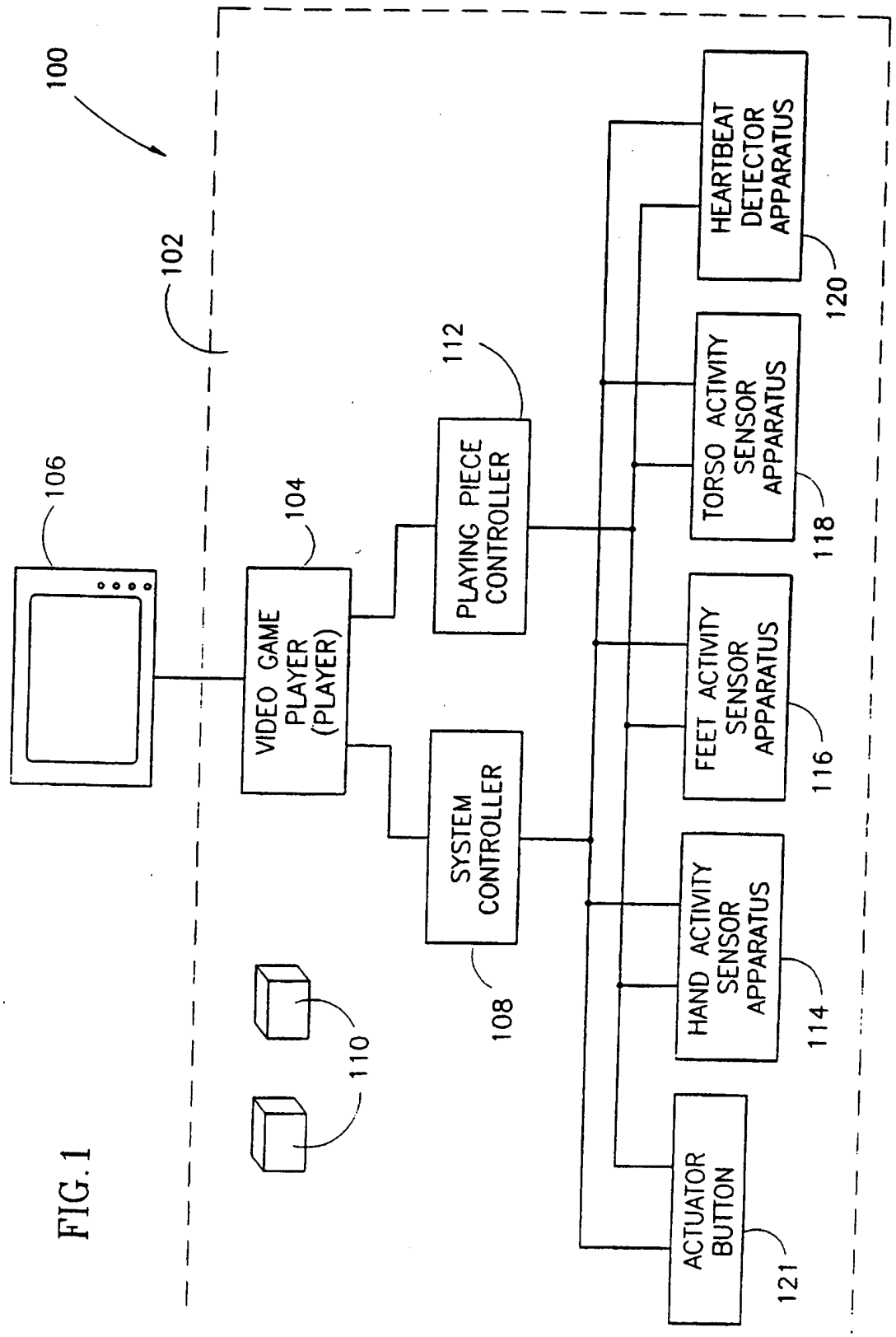

100
102
106
104
VIDEO GAME PLAYER (PLAYER)
112
PLAYING PIECE CONTROLLER
108
SYSTEM CONTROLLER
110
HEARTBEAT DETECTOR APPARATUS
120
TORSO ACTIVITY SENSOR APPARATUS
118
FEET ACTIVITY SENSOR APPARATUS
116
HAND ACTIVITY SENSOR APPARATUS
114
ACTUATOR BUTTON
121

FIG. 1

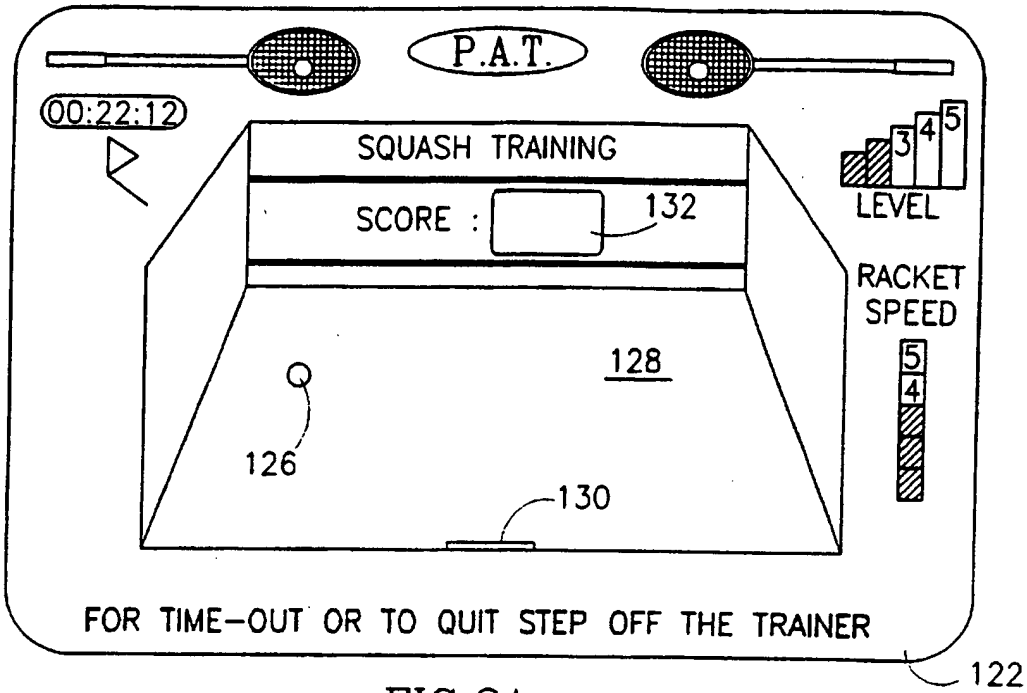

P.A.T.
00:22:12
SQUASH TRAINING
SCORE :
132
LEVEL
3
4
5
RACKET SPEED
5
4
128
126
130
FOR TIME-OUT OR TO QUIT STEP OFF THE TRAINER
122

FIG.2A

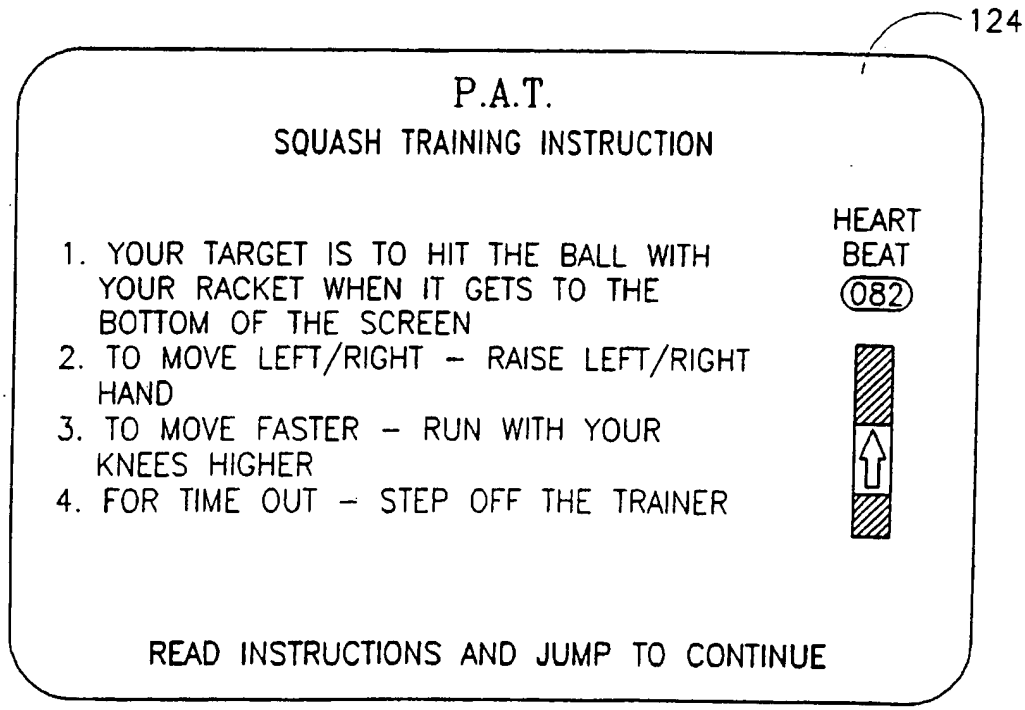

124
P.A.T.
SQUASH TRAINING INSTRUCTION
1. YOUR TARGET IS TO HIT THE BALL WITH YOUR RACKET WHEN IT GETS TO THE BOTTOM OF THE SCREEN
2. TO MOVE LEFT/RIGHT - RAISE LEFT/RIGHT HAND
3. TO MOVE FASTER - RUN WITH YOUR KNEES HIGHER
4. FOR TIME OUT - STEP OFF THE TRAINER
HEART BEAT
082
READ INSTRUCTIONS AND JUMP TO CONTINUE

FIG.2B

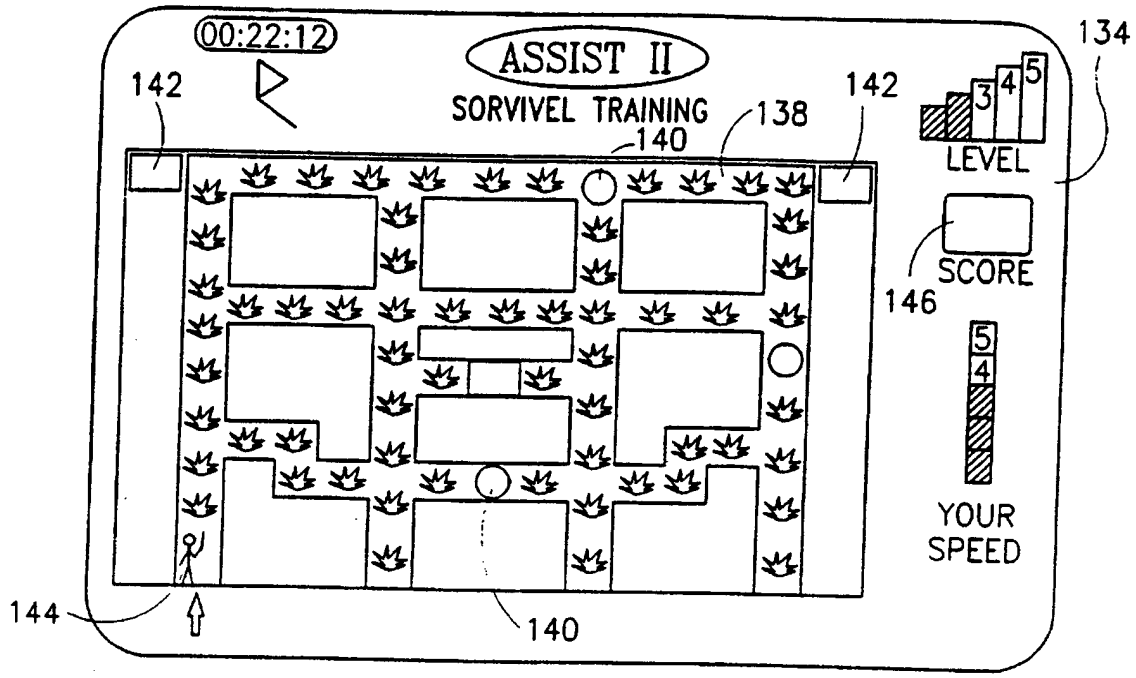


FIG.2C

ASSIST II

SORVIVEL TRAINING

TRAINING RULES

1. YOUR TARGET IS TO CLEAR ALL WAYS IN THE JUNGLE WITHOUT GETTING HURT FROM THE ANIMALS
2. YOU CAN HUNT THE ANIMALS FOR 3 SECONDS AFTER YOU CATCH AN APPLE

OPERATIONAL INSTRUCTION

1. TO MOVE FASTER – RUN FASTER
2. TO MOVE UP – RUN AND RAISE BOTH HANDS
3. TO MOVE LEFT/RIGHT – RUN AND RAISE LEFT/RIGHT HAND
4. TO MOVE DOWN – RUN WITH YOUR HANDS DOWN
5. FOR TIME OUT – STEP OFF THE TRAINER

FIG.2D

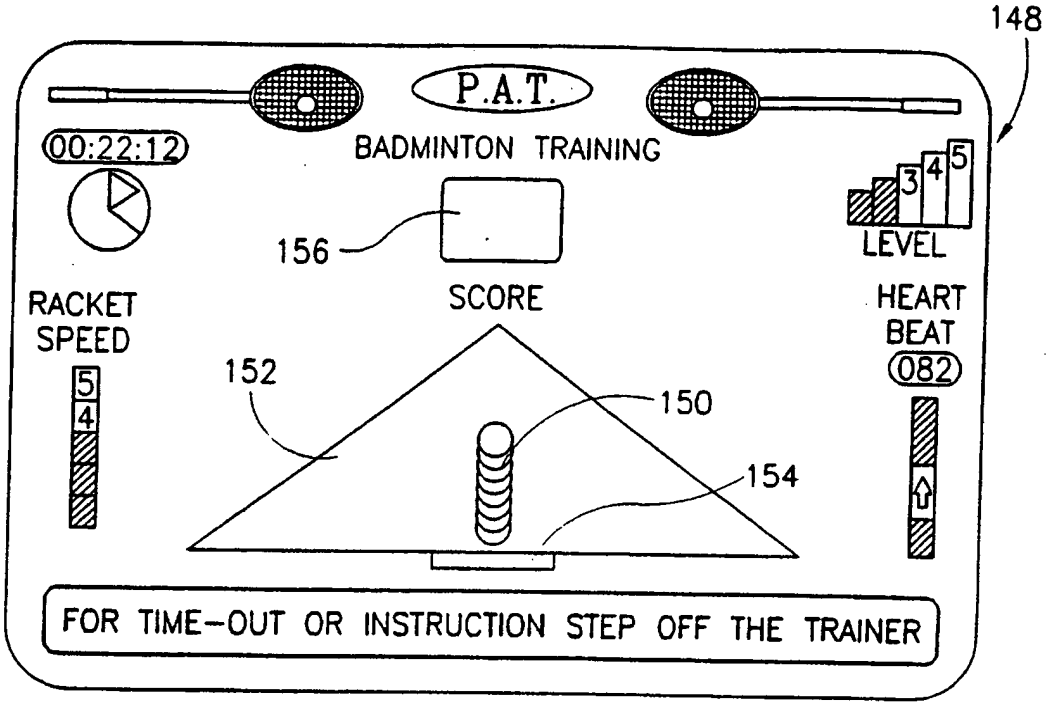

148
P.A.T.
00:22:12
BADMINTON TRAINING
156
LEVEL
RACKET SPEED
SCORE
HEART BEAT
082
152
150
154
FOR TIME-OUT OR INSTRUCTION STEP OFF THE TRAINER

FIG.2E

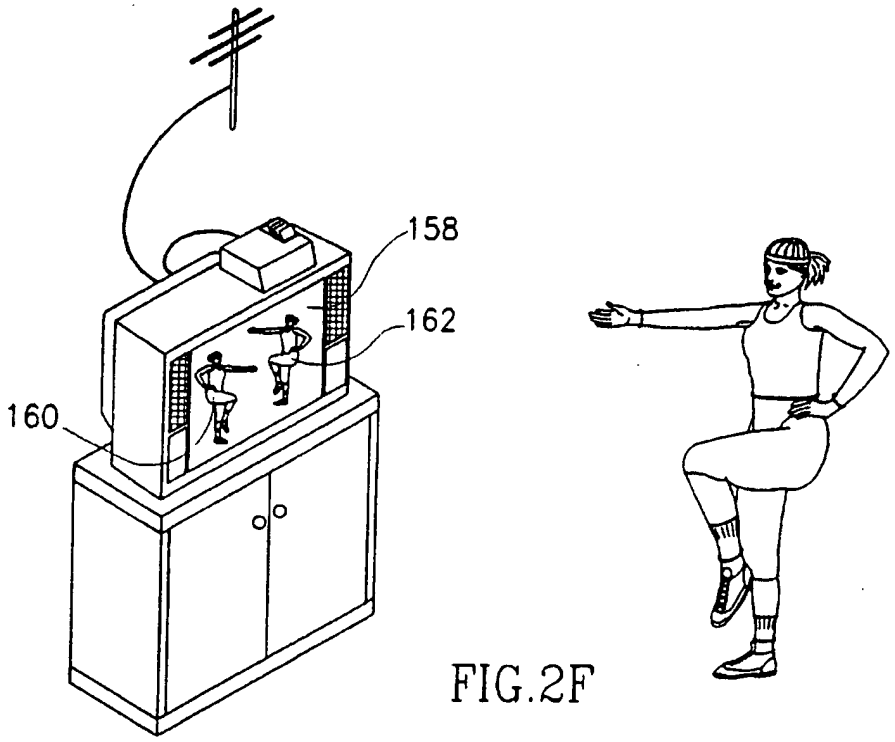

158
162
160

FIG.2F

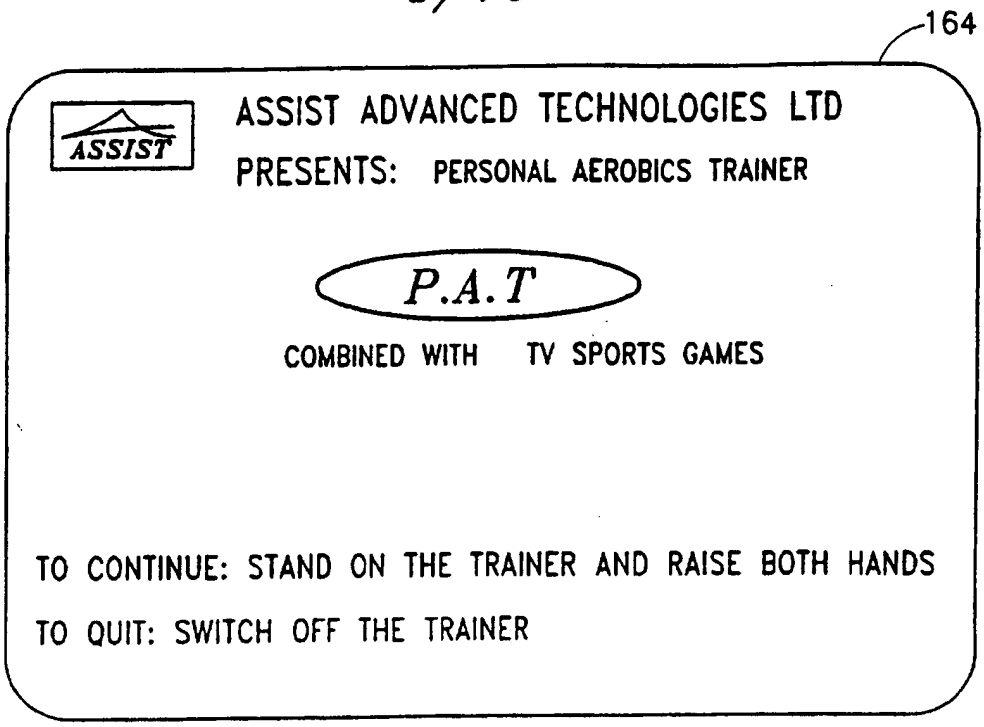

164
ASSIST
ASSIST ADVANCED TECHNOLOGIES LTD
PRESENTS: PERSONAL AEROBICS TRAINER
P.A.T
COMBINED WITH TV SPORTS GAMES
TO CONTINUE: STAND ON THE TRAINER AND RAISE BOTH HANDS
TO QUIT: SWITCH OFF THE TRAINER

FIG.3A

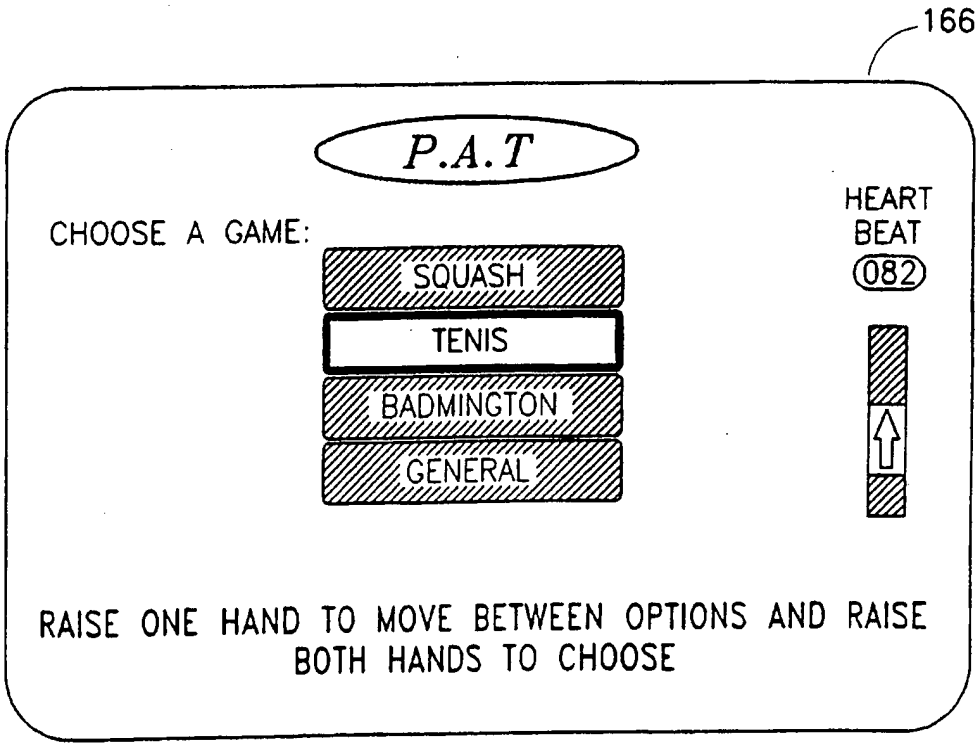

166
P.A.T
CHOOSE A GAME:
SQUASH
TENIS
BADMINGTON
GENERAL
HEART BEAT
082
RAISE ONE HAND TO MOVE BETWEEN OPTIONS AND RAISE BOTH HANDS TO CHOOSE

FIG.3B

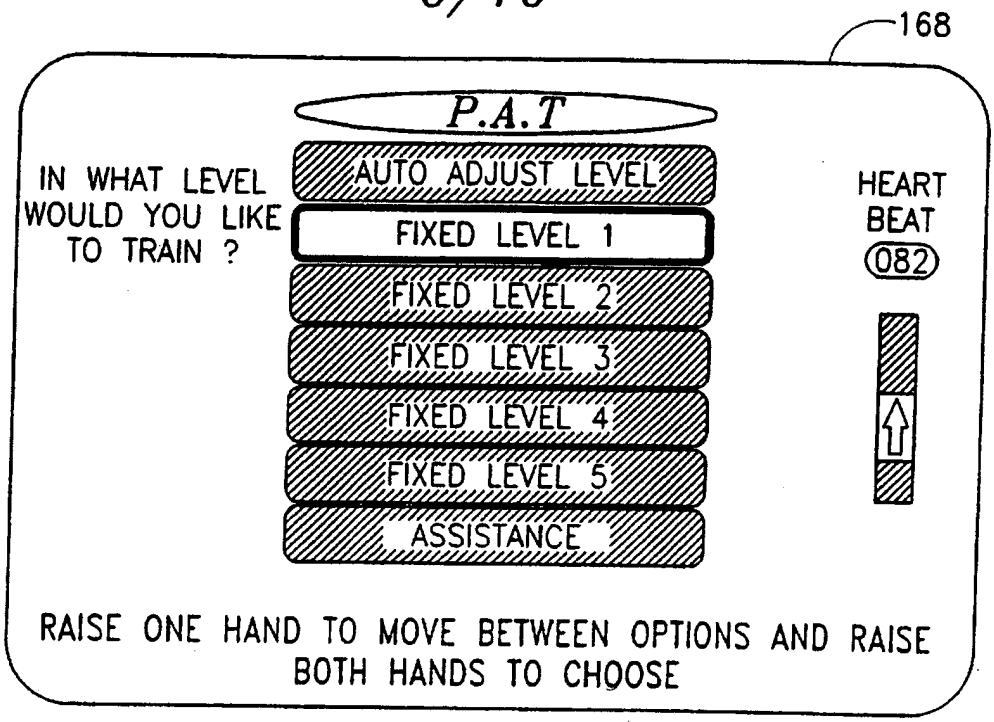

168
P.A.T
IN WHAT LEVEL WOULD YOU LIKE TO TRAIN ?
AUTO ADJUST LEVEL
FIXED LEVEL 1
FIXED LEVEL 2
FIXED LEVEL 3
FIXED LEVEL 4
FIXED LEVEL 5
ASSISTANCE
HEART BEAT
082
RAISE ONE HAND TO MOVE BETWEEN OPTIONS AND RAISE BOTH HANDS TO CHOOSE

FIG.3C

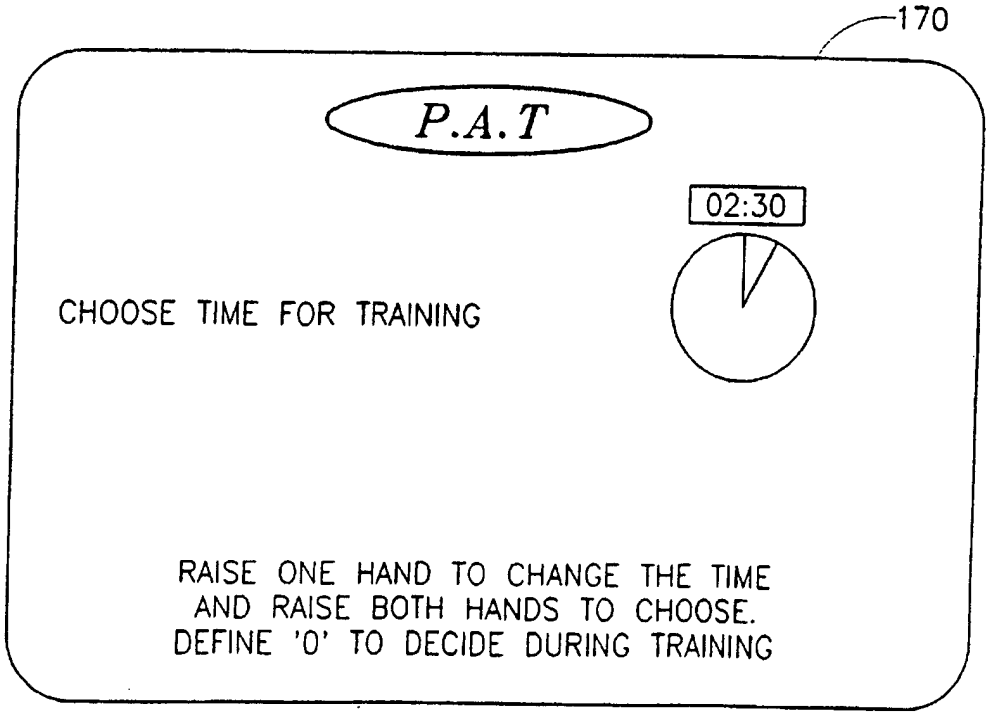

170
P.A.T
02:30
CHOOSE TIME FOR TRAINING
RAISE ONE HAND TO CHANGE THE TIME AND RAISE BOTH HANDS TO CHOOSE. DEFINE '0' TO DECIDE DURING TRAINING

FIG.3D

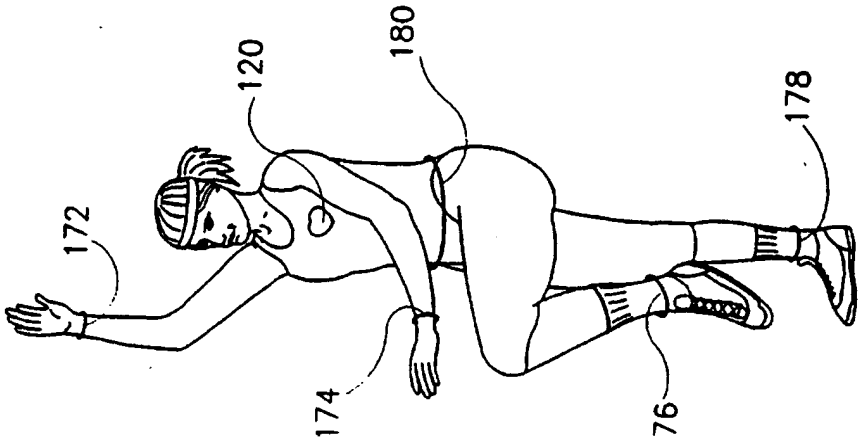
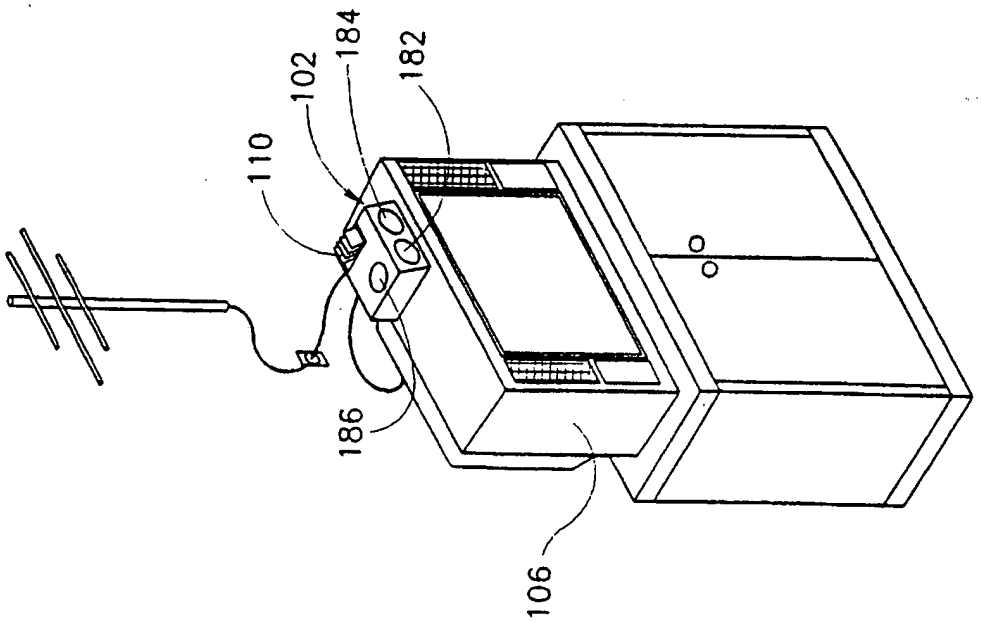


FIG.4



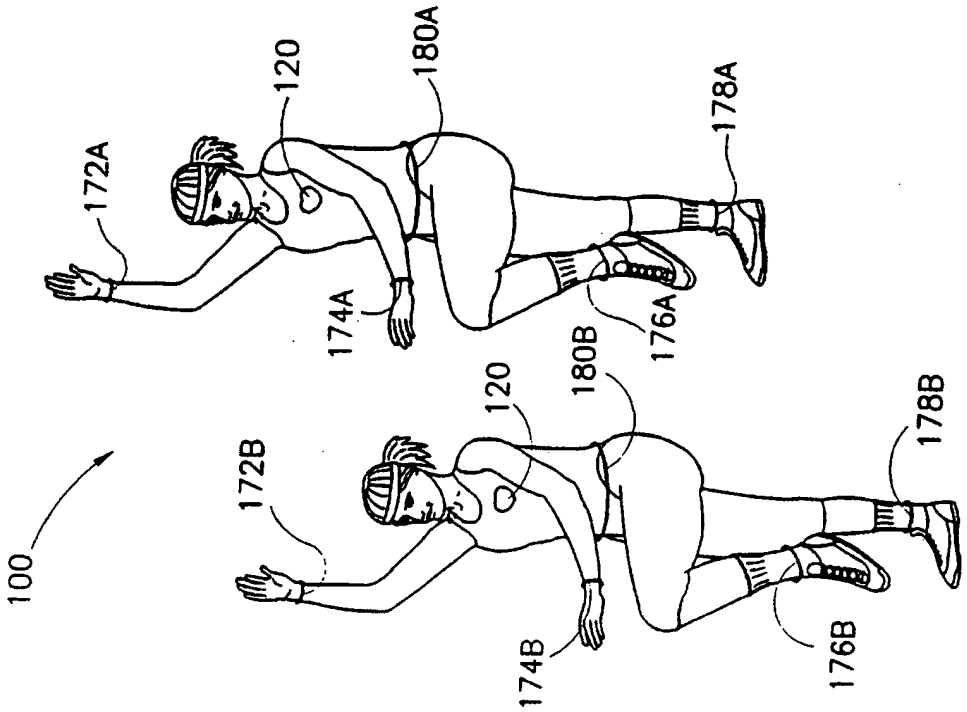
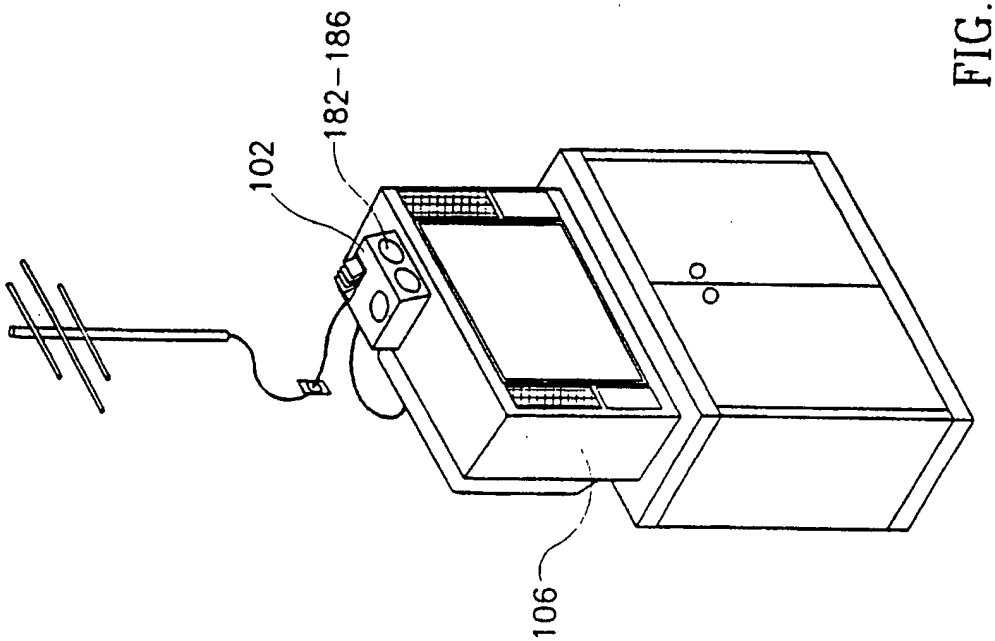

100
172A
120
180A
178A
174A
176A
172B
120
180B
178B
174B
176B

FIG.5


102
182–186
106

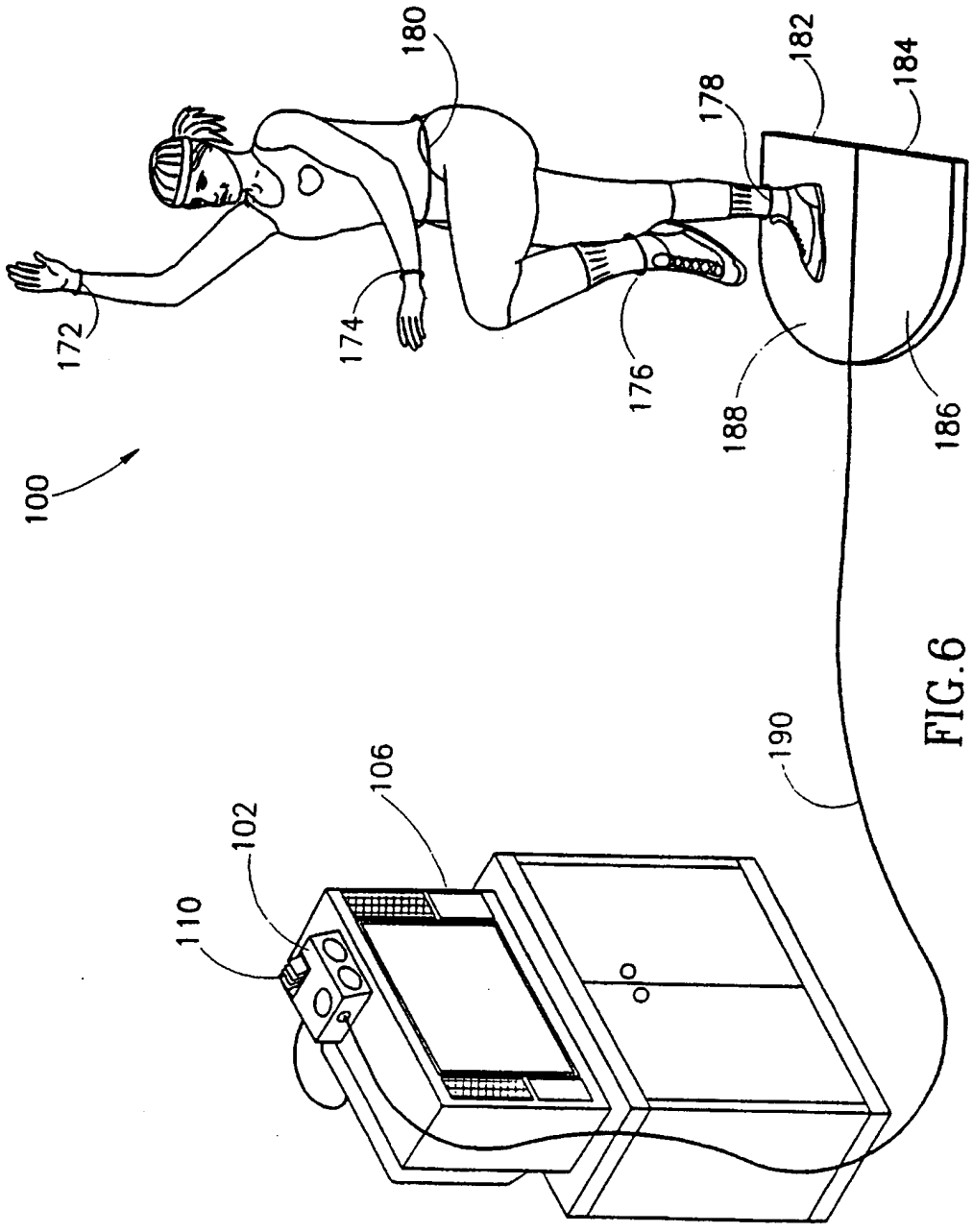


FIG.6

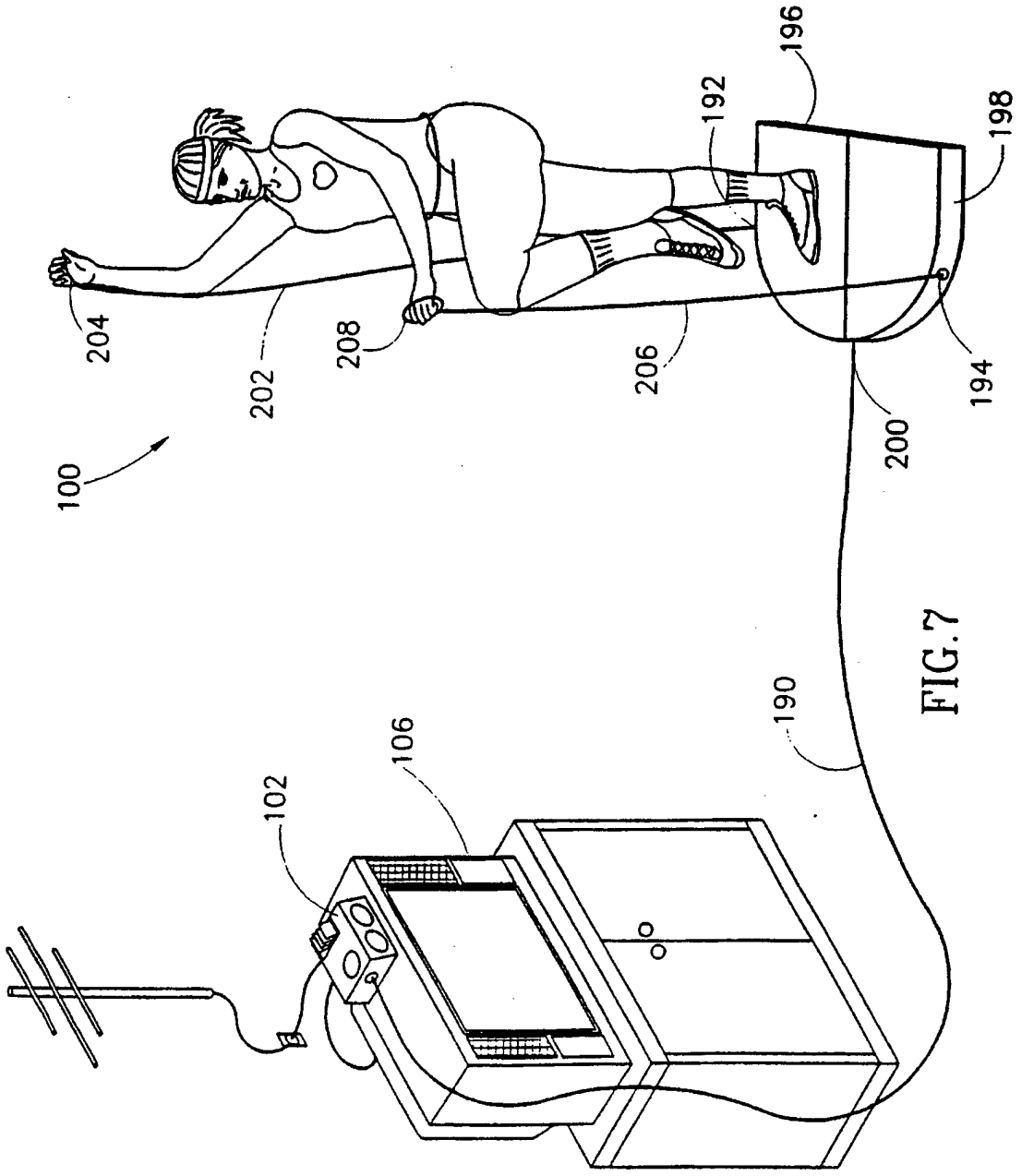


FIG.7

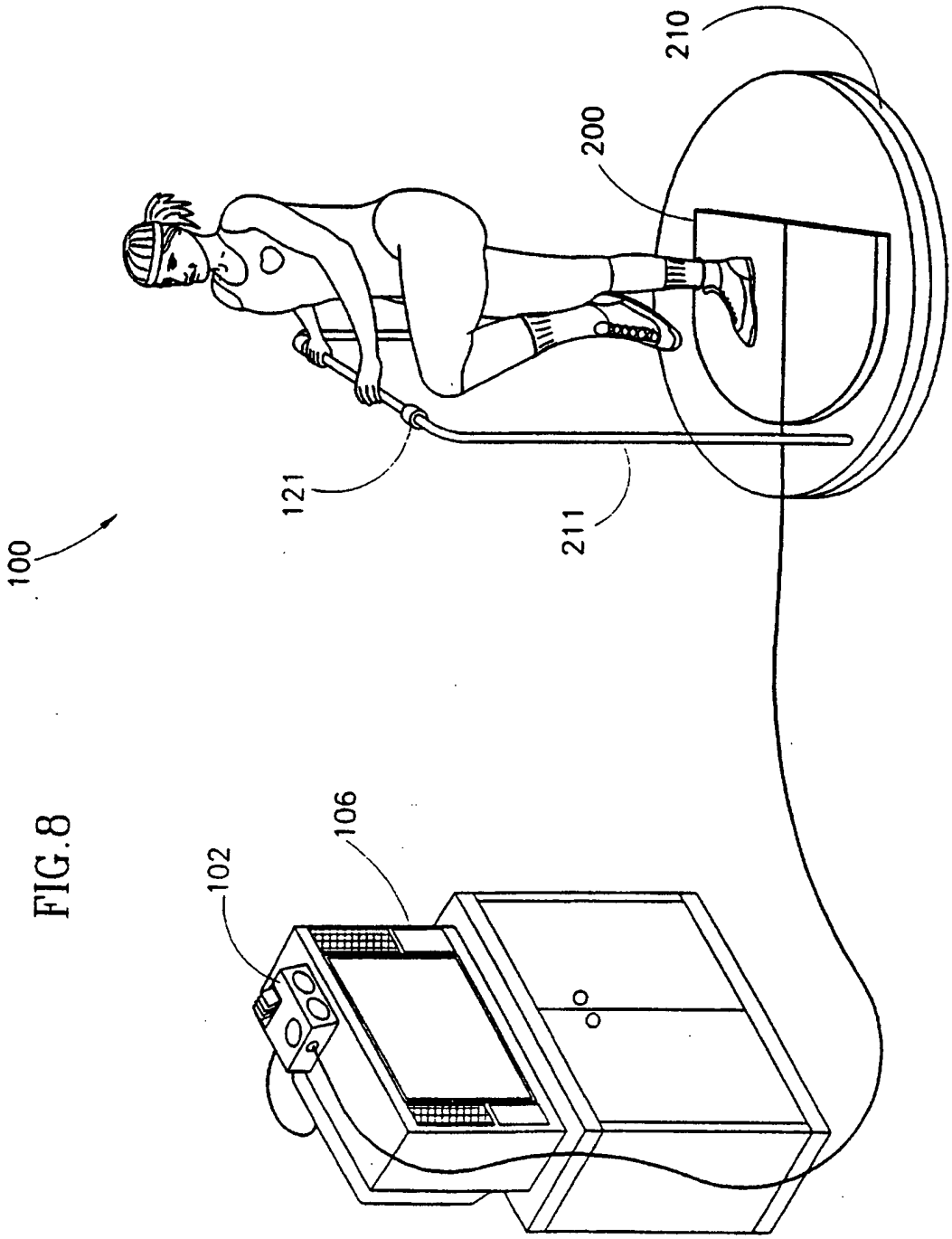


FIG.8

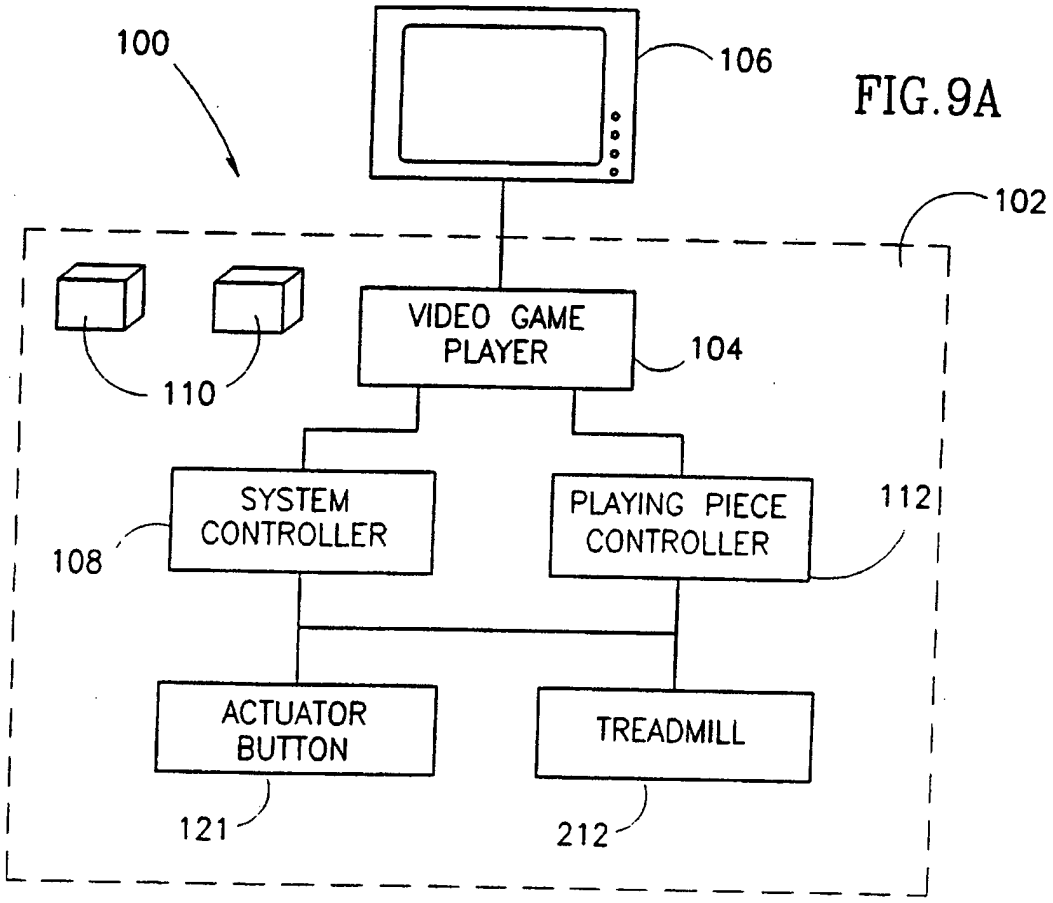


FIG.9A

SCREEN REFRESHES

5	4	3	2	1	TIME BETWEEN 2 HANDS SWITCHES IN MILLISECONDS
0	0	0	0	0	Y<200
0	0	0	0	1	160< Y<200
0	0	0	1	2	120< Y<160
0	0	1	2	3	90< Y<120
0	1	2	3	4	Y<90

FIG.13

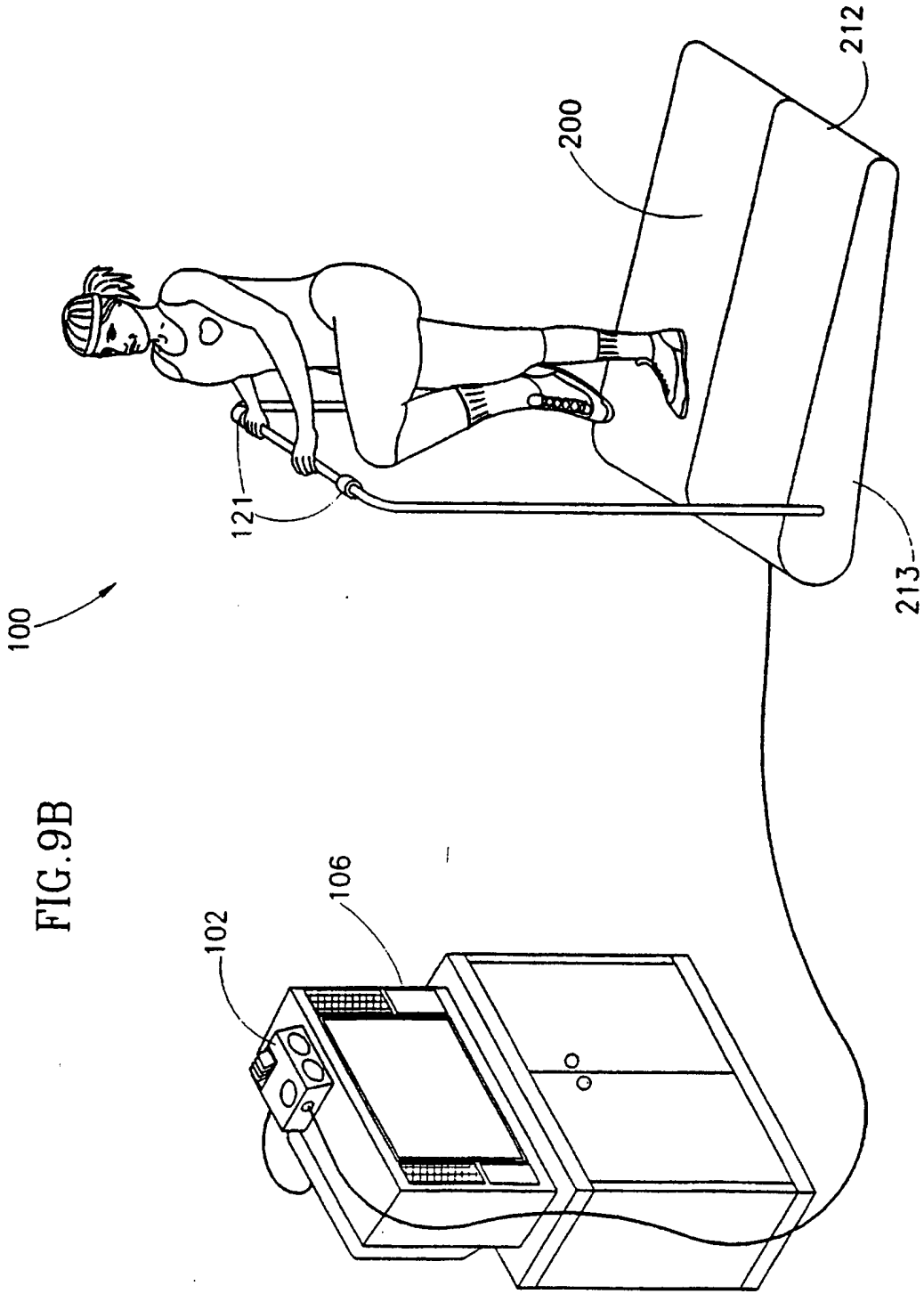


FIG.9B

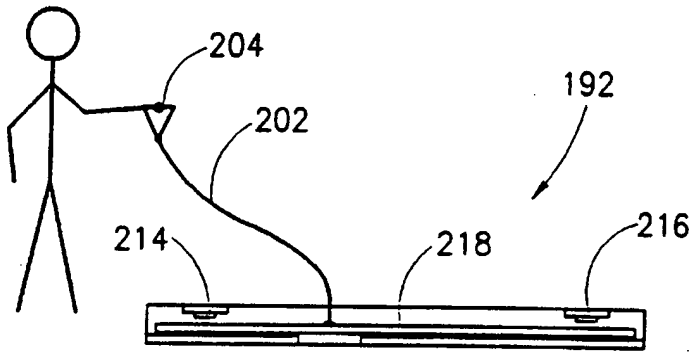


FIG.10A

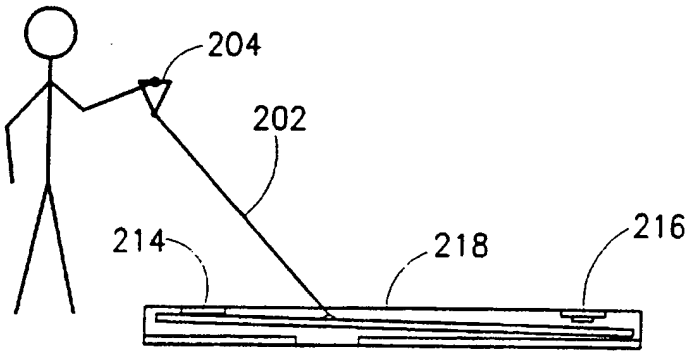


FIG.10B

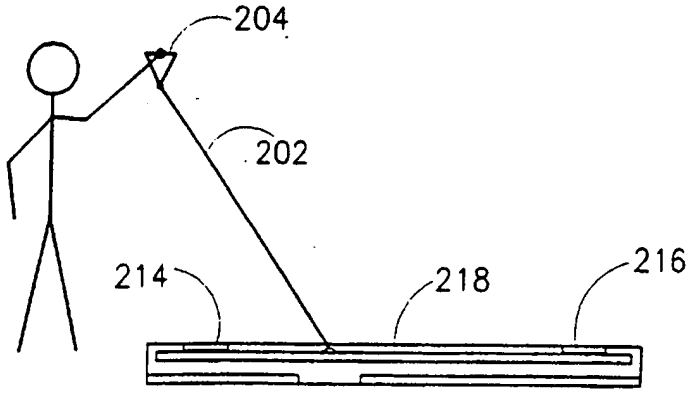


FIG.10C

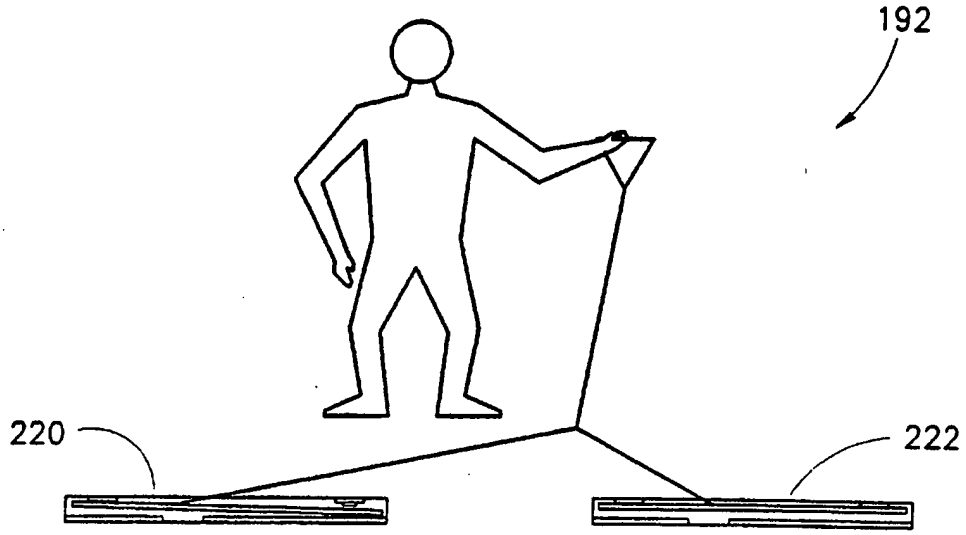


FIG.11A

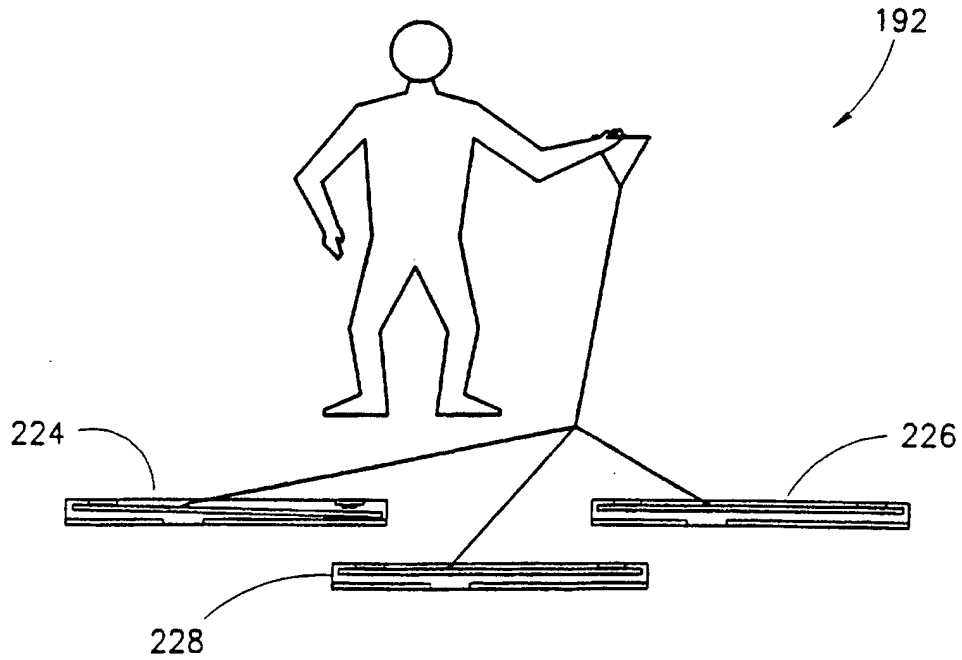


FIG.11B

LEVELS OF USER'S AEROBIC ACTIVITY	HEAVY WALKING	WALKING	JOGGING	RUNNING	FAST RUNNING	SPRINTING
AIRBORNE PERCENTAGE	−40% > P	−40%−0%	0−24%	24−50%	50−70%	70% < P
FREQUENCY						
f < f	0	0	0	0	0	0
1, 2	0	2	3	4	5	6
3, 4, 5	0	3	4	5	6	7
6, 7	0	4	5	6	7	8
f > 8	0	5	6	7	8	9

FIG.12

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/10694

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :A61B 5/04; A63B 26/00; G09G 3/02
US CL :482/4, 902
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 273/1248B, 434, 438; 482/1-8, 74, 79, 900-902

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 5,288,078 (CAPPER ET AL.) 22 February 1994, see entire document.	1, 2, 10, 11, 17, 18
A	US, A, 4,925,189 (BRAEUNIG), 15 May 1990, see column 3 lines 52-64.	8
A	US, A, 5,125,647 (SMITH) 30 June 1992, see entire document.	2-5, 16
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☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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05 OCTOBER 1995	11 DEC 1995
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